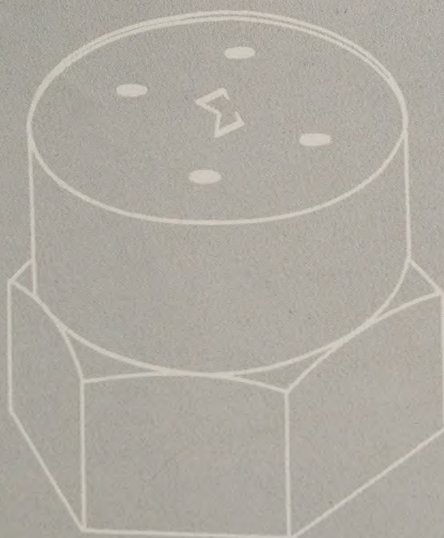


9219

ENDEVCO Σ

9219
INSTRUCTION MANUAL
SERIES 2200
ACCELEROMETERS



symbol of excellence...



ENDEVCO CORPORATION

161 East California Street, Pasadena, California



ENDEVCO TRANSDUCERS



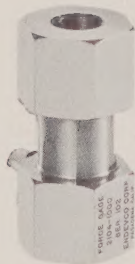
Accelerometers

Series 2200 features small size, light weight (0.3 oz.), and large, self-generated output (10 mv/G), without reduction of high natural frequency (40 KC), or large range (50,000 G) for vibration or shock tests.



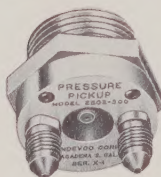
Pressure Pickups

Series 2500 features high ring frequency (55 KC), self-generated outputs (40 mv/psi), and small diaphragm dimensions, for measurement of transient pressures in ranges to 2500 psi for combustion, shock, or pressure wave measurement.



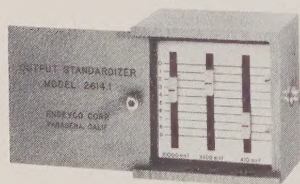
Force Pickups

Series 2100 is available for dynamic measurement of force to 5000 pounds with outputs of 30 millivolts per pound for measurement of thrust, forcing functions, drop tests, shock absorbers, etc.



2200°F Pickups

Accelerometers and pressure pickups are available in artificially cooled housings for use under high temperature conditions without loss of measurement accuracies.



Output Standardizers

Voltage levelers in 0.1% steps are ideal for setting all pickups to the same output sensitivity per unit of measurement improving low frequency response without affecting the high frequency response.

Dynamic self-generating piezoelectric pickups are finding wide use in test programs because of their basic design characteristic which generates large outputs for the changing or dynamic variables and suppresses the DC or quiescent values.

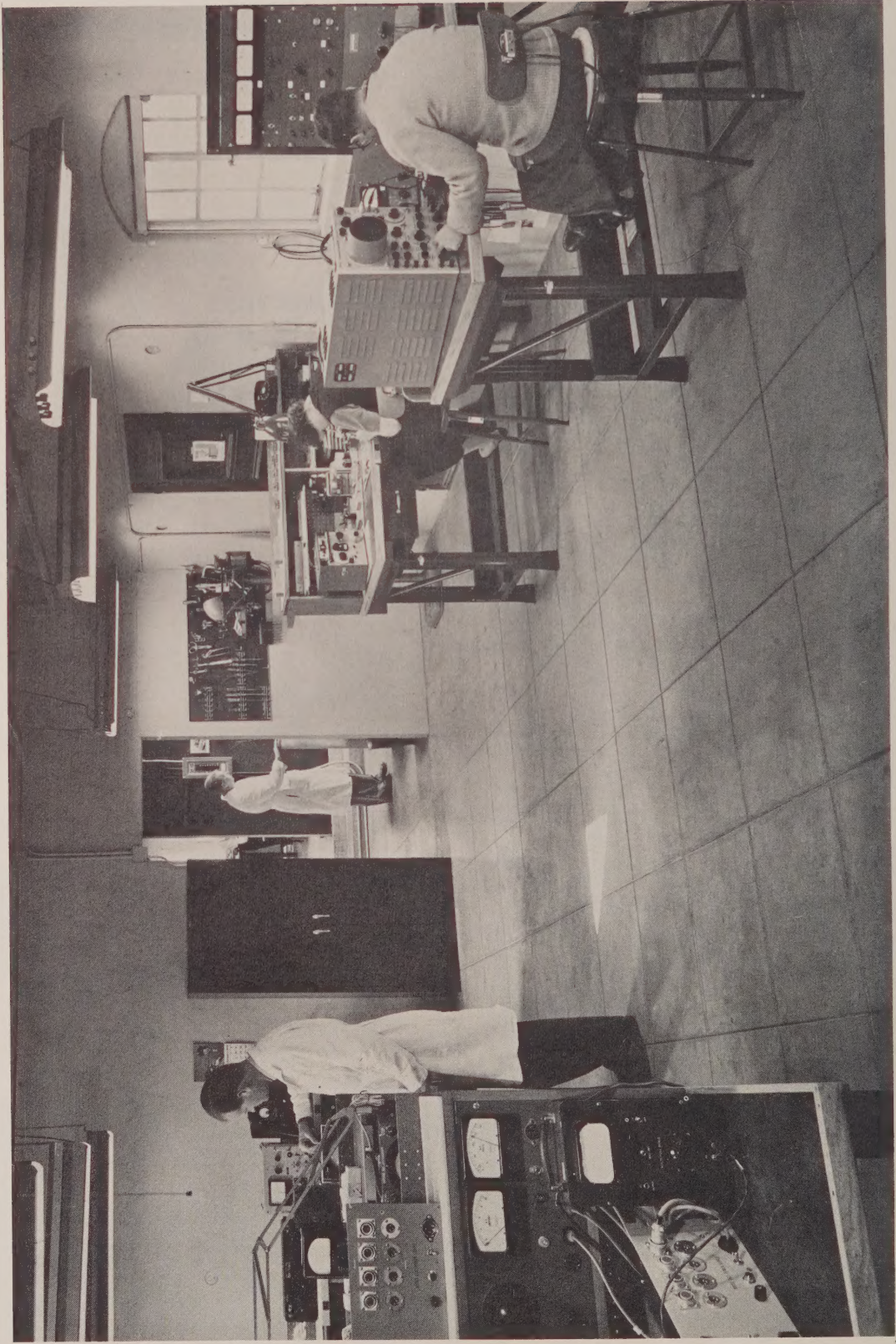
GENERAL TRANSDUCER DESCRIPTION

High frequency response and wide ranges (2 cps to 55 KC) suggest the extremes that this pickup features without loss of high output characteristics. Individual pickup calibrations provide the user with authoritative data for use as a secondary dynamic, acceleration, pressure, and force standards.

INSTRUCTION MANUAL
SERIES 2200 ACCELEROMETERS

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Quality Control - Electronic Section

I INSTRUCTIONS

1.1 General Description

Endevco Series 2200 Accelerometers are piezoelectric transducers designed to provide reliable measurements of vibratory or transient accelerations. They provide a large self-generated voltage directly proportional to acceleration, linear over a frequency range from 2 cps to as high as 15,000 cps. They are linear with temperature over wide regions and are small and rugged in construction. The Descriptive Data in Section V at the end of this Manual provides individual accelerometer specifications. For a complete discussion of the characteristics of all piezoelectric transducers see Bulletin No. 2.31 - 2000 - 1.1 "Instructions for the Applications of Piezoelectric Transducers."

1.2 Determination of Voltage Sensitivity on any Application

Each accelerometer is provided with an exact sensitivity calibration with exactly 100 micromicrofarads of cable capacity connected to the accelerometer. The sensitivities are provided as E_C in rms millivolts per single peak (vector) g and E_S in peak millivolts per single peak (vector) g , which is exactly $1.41 \times E_C$. When observing the signal levels on an rms VTVM use E_C as the calibration value. When measuring single peak voltages on meters or records use E_S as calibration sensitivity. When measuring peak to peak voltages use $2 \times E_S$ as Accelerometer sensitivity.

When the accelerometer is operated with either more or less than 100 mmfd shunt capacity in the form of cables, connectors, and residual capacity in matching amplifiers (residual capacity of Endevco cathode followers and amplifiers is 15 mmfd except for 2614 and 2616 Standardizing Amplifiers which have 25 mmfd residual input capacity) the basic sensitivity is shifted down or up by a calculated amount. The new sensitivity should be determined from the following equation:

$$E = E_C \frac{(C_P + 100)}{(C_P + C_t)} \text{ rms mv/single peak g} \quad (1)$$

Where: E_C is factory supplied calibration sensitivity in rms mv/single peak g (calibrated with 100 mmfd, external cable capacitance loading):

E is actual sensitivity for any total external capacitive loading of C_t on the accelerometer:

C_P is the accelerometer capacitance alone in mmfd, and is supplied as a factory calibration:

C_t is total externally applied capacitance (including cable) in mmfd.

1.3 Standardization of Accelerometer Sensitivity to any Desired Value

The Endevco Model 2614 and 2616 Input Amplifiers or Model 2614.1 Output Standardizer include a three-decade step capacitor adjustment that allows discrete capacities to be added in shunt across any accelerometer in 10 mmfd steps up to 10,000 mmfd. These decade capacitors make it possible to standardize the sensitivity of any accelerometer to any value E less than its original calibration E_C such as 10.0 rms millivolts per g so that g's instead of millivolts can be read directly from the scale of any vacuum tube voltmeter without interpolation. In other instances where very high g levels

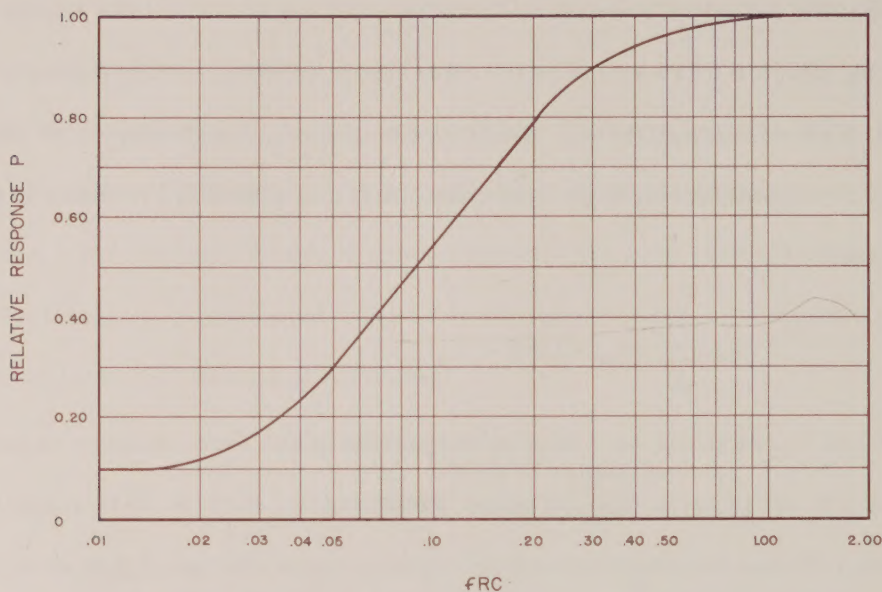
are expected it may be necessary to reduce the sensitivity of the accelerometer by a factor of 10 or more in order not to exceed the 5 volt rms limit of most Endevco Amplifiers. To arrive at the exact capacity to be added to any accelerometer for a desired value of E use equation (1) above in this new form:

$$C_t = \frac{E_c}{E} (C_p + 100) - C_p \quad (2)$$

Once C_t is known it can be added to the pickup in the form of cable capacity or capacity set into the three-decade switch of the 2614 or 2616 Amplifier or 2614.1 Output Standardizer and the voltage out of the amplifier as a gain of 1 will be exactly the desired E.

1.4 Requirement for High Impedance Matching Amplifier or Cathode Follower

Piezoelectric accelerometers are very high impedance devices requiring a high impedance matching amplifier for linear operation. Endevco 100 megohm input impedance cathode followers are recommended when flat ($\pm 5\%$) frequency response down to 10 to 20 cps is required. Endevco 1000 megohm input impedance amplifiers are recommended when flat frequency response ($\pm 5\%$) below 5 cps is required. Only when high frequency transient measurements are being made is less than 100 megohms matching impedance recommended. Actual response at any frequency can be measured from Figure 1 where: f is the frequency in cps; r is the input impedance in ohms of the matching amplifier; c is the total capacitance in farads of the accelerometer, plus additional applied shunt capacity, if any.



LOW FREQUENCY RESPONSE VS LOADING

Figure 1

Example: If frequency (f) of desired measurement is 10 cps, total capacitance (c) of accelerometer and cable is 300 mmfd, and amplifier input impedance (r) is 100 megohms (Endevco Cathode Follower), we can determine

$$f \times r \times c = 10 \times 100 \times 10^6 \times 300 \times 10^{-12} = 0.30.$$

Using Figure 1, we find relative response (p) corresponding to frc = 0.3 is 89% indicating signal at 10 cps to be down approximately 11%.

Using input impedance (r) of 1000 megohms (Endevco Amplifiers):

$$frc = 10 \times 1000 \times 10^6 \times 300 \times 10^{-12} = 3.0.$$

Relative response (p) will be essentially 100%.

1.5 Linearity with Temperature

Endevco has developed a series of piezoelectric materials for use in their accelerometers to provide accurate measurements independent of ambient temperatures. Figure 2 shows the temperature characteristics of all

Endevco accelerometers using a PIEZITE element, Type I, and Figure 3 shows the temperature characteristics of accelerometers using a PIEZITE element, Type II, for operation to 500°F. These graphs may be used to apply small percentage correction factors to give extreme accuracies at any temperature.

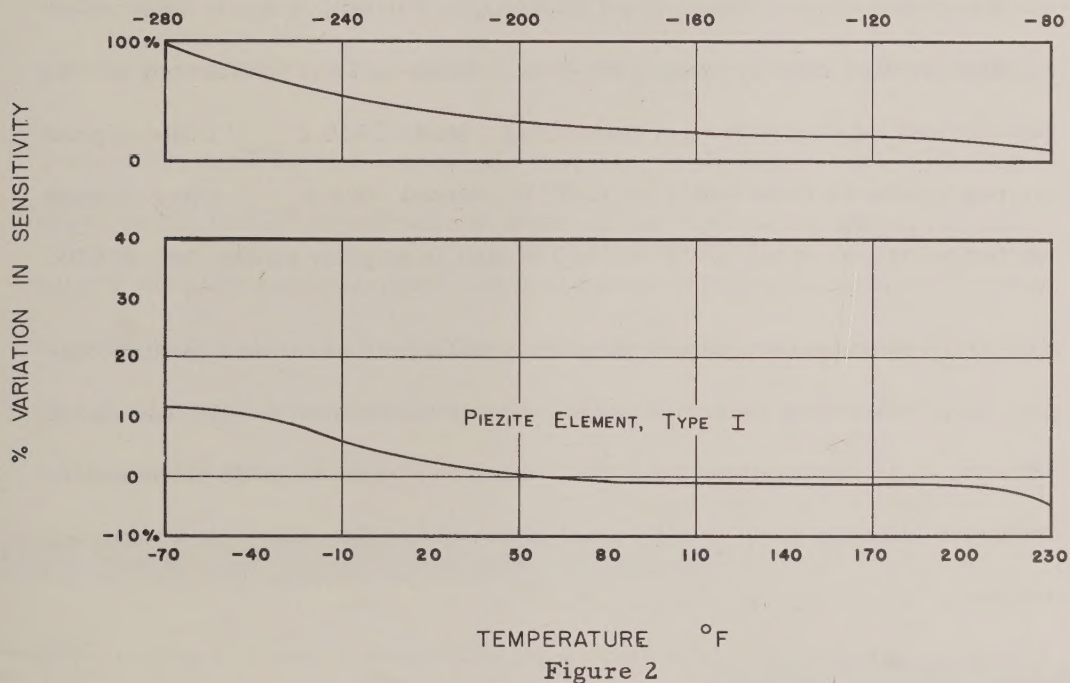


Figure 2

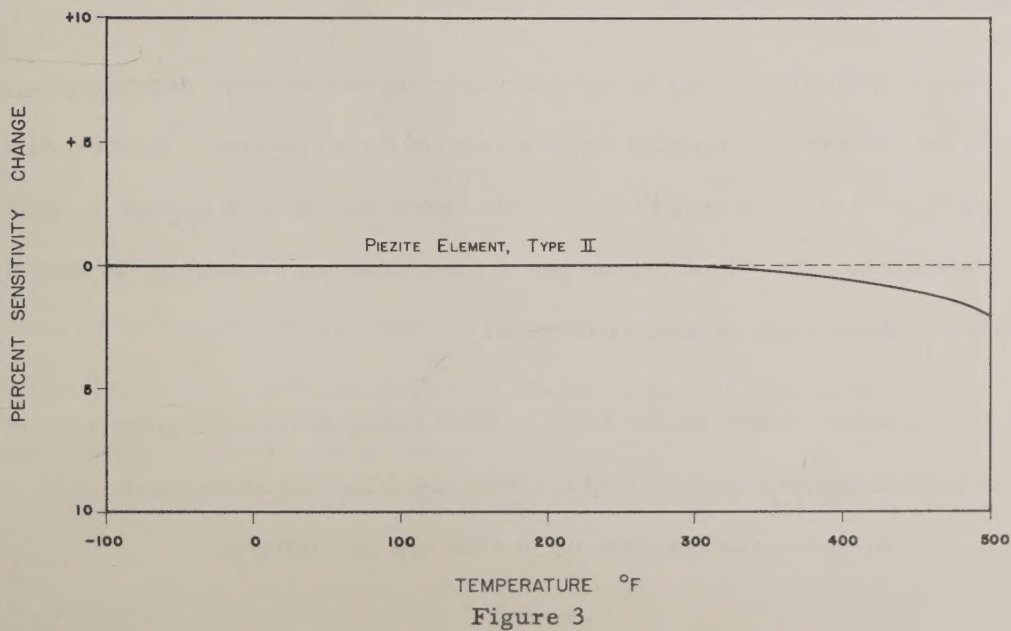


Figure 3

1.6 Cable

A selected and noise treated Cable three feet in length is supplied with each accelerometer (other lengths may be ordered as well). Untreated cable will generate very large voltages (200 times treated cable) when flexed or vibrated, sometimes obscuring the signal. For this reason only cables supplied by this factory should be used. Each cable is calibrated for its capacity and marked with a permanent tag. Model 3030 x ____" cable is good for temperatures from -20°F to $+175^{\circ}\text{F}$. Model 3090 x ____" cable is good for temperatures from -65°F to $+500^{\circ}\text{F}$ and is slightly stiffer than #3030.

Excessive vibration or whip of connecting cable may cause undesirable output. This effect is greater at low frequencies and becomes negligible above 500 cps. It is recommended that the cable be secured 1" to 2" from accelerometer allowing $1/4$ " to $3/8$ " slack between accelerometer and securing device.

1.7 Accelerometer Mounting

The accelerometer may be mounted in a variety of ways depending upon the application and practical requirements of the test system. If stud mounting is used the mounting torque should be roughly 18 inch pounds to insure a secure mount. Mounting torque has no effect on sensitivity as long as the accelerometer is securely mounted.

Accelerometers with tapped holes in their bases for mounting are supplied with mounting stud adaptors which offer the following advantages:

- (a) Accurate response up to 4000 cps and 100 g's

- (b) Raises the accelerometer approximately .015 inches above the surface which may be rough, irregular or under flexure.

The studs should not be used for very high g level measurements or for very high frequency shock work, in which case the full mounting surface of the base of the accelerometer should be accurately mated against the object under test for full transmission of the highest frequency information.

The accelerometers with tapped hole mounting in their base may be mounted very readily on any object without drilling and tapping any holes. Double-backed adhesive tape manufactured by Minnesota Mining and Manufacturing (Scotch) or Polyken can be used to stick the accelerometer to any reasonably flat surface for accurate measurements up to 2000 cycles and approximately +1000 g to -20 g.

1.8 Effect of Accelerometer Mass on Test Specimen

Adding mass to a test system reduces the test system's resonant frequency

(f_r) to

$$\left[\frac{M}{M_a + M} \right]^{1/2} \times f_r \quad (3)$$

Where: M = test specimen mass
 M_a = added mass such as accelerometer

If the added mass is 20% of M the f_r of the test specimen will be reduced to 90% of its original value. It is therefore important when testing small systems to choose accelerometers with low mass so that their effect on the system under test will be negligible.

II CALIBRATION PROCEDURE

2.1 General

All accelerometers are individually aged, cycled and calibrated for sensitivity, frequency response and cross-axis sensitivity. A complete record is kept on file for each unit.

2.2 Sensitivity Measurement

The basic sensitivity for each accelerometer is measured at 10 g's and 50 cps. Frequency is controlled by a time calibrator and displacement is measured with a high resolution microscope viewing an illuminated light spot on a vibrating shaker. (See Figure 4) A very small light spot is created by using fine grit emery paper illuminated by a bright spot light. A large number of sensitivity measurements are made on each accelerometer during its aging and cycling period to assure complete stability. The calibration process is repeatable within 1%. The outline of possible sources of error below are an indication of the absolute accuracy than can be expected from the factory calibration.

Frequency Error:

Frequency is maintained to one part in 10^3 , which can result in a calibration error of 0.2%.

Distortion:

Distortion is determined by the notch filter technique using the output of the accelerometer under test. The distortion in g units is maintained less than 10%. Ten percent amplitude of second harmonic distortion phased for maximum effect of peak to peak amplitude

will have the maximum effect on accuracy, which would result in an error of approximately 2.5%.

Vibration of the Optical System:

The microscope and vibration excitor are both mounted on a 1 cps seismic mass, whose mass is approximately 500 times that of the vibrating system, which could result in an error due to microscope vibration of 0.2%.

Resolution and Accuracy of the Optical System:

The frequency of 50 cps and amplitude of 10 g was specifically chosen in order to obtain the optimum results on the particular optical system in use. This results in the determination of the amplitude of vibration within 0.5%.

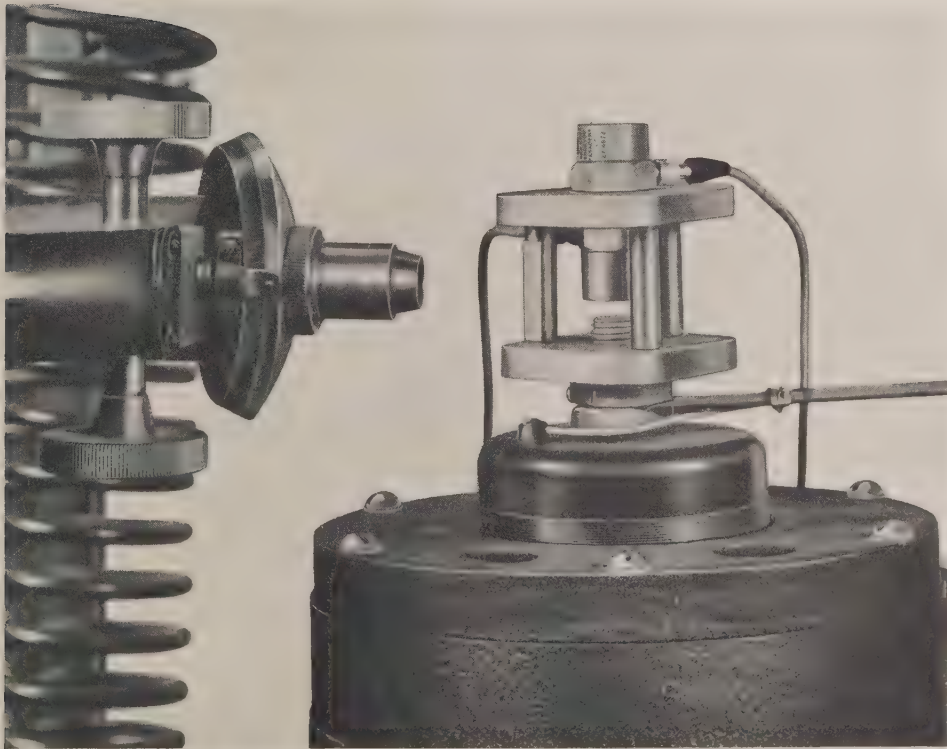


Figure 4

Total Calibration Error:

The usual (root means square) method of determining accuracy of calibration would render a calibration accuracy of 2.6%; however, if all errors were additive and assumed maximum, calibration error would be within 3.4%.

2.3 High Frequency Response Calibration

The question often arises as to how a high frequency accelerometer is calibrated to determine its linearity at high frequencies and how it may be checked in the field.

At low frequencies up to several hundred cycles the sensitivity of an accelerometer is determined very accurately on a vibration generator by measuring the frequency of vibration and using a microscope to measure the amplitude of vibration. Accurate g levels cannot be computed above 200 cps, however, because displacements for reasonable g values become so small as to be unresolvable by ordinary microscope techniques without resorting to an interferometer. Interferometers provide, theoretically at least, very high resolution of small displacements but in practice they are extremely complex to use and maintain with the resulting accuracy questionable and very dependent on operator technique.

THEORETICAL RESPONSE:

The theoretical frequency response of a piezoelectric pickup which is virtually an undamped ($h=0$) dynamic system is shown in the following equation:

$$R = \frac{1}{1-B^2} \quad (4)$$

Where: B = the ratio of operating frequency to natural frequency.

It can be seen from this equation that when operating at $1/5$ the natural frequency, R is equal to 1.04 which means that the sensitivity of the accelerometer is 4% higher at that frequency than at the lower frequencies. It is for this reason that all Endevco accelerometers are rated for linear frequency response $\pm 5\%$ to $1/5$ of their natural frequency. Numerous tests in our laboratory and in other leading research and development laboratories have shown that the actual piezoelectric pickups follow this theoretical response curve very closely.

HIGH FREQUENCY CALIBRATION:

To actually calibrate accelerometers to high frequencies a "reciprocity" technique was developed.^{1,2,3,4} Estimated accuracy of this technique⁵, is 2% at frequencies below 1000 cps to 6% at 10 KC. Independent experimental checks confirm this figure. The reciprocity technique of calibration

- NOTES: 1 Journal of the Acoustical Society of America, Sept. 1948, Pg 637
2 " " " " " " " Nov. 1950, Pg 881
3 " " " " " " " July 1952, Pg 384
4 National Bureau of Standards Report No. 2714, Oct. 1956
5 " " " " " " 2654, Pg 109

is a long and tedious one and it is impractical to calibrate each accelerometer in this manner. Instead, each Endevco production accelerometer is calibrated by comparing its output with that of a reciprocity-calibrated accelerometer. The test accelerometer and the reciprocity-calibrated accelerometer are mounted back to back with their sensitive axes coinciding on a frame attached to a vibration generator. (See Figure 4) The ratio of the outputs of the two accelerometers together with the known frequency response of the reciprocity-calibrated accelerometer gives an accurate determination of the frequency response of the test accelerometer. This data is plotted and supplied with each accelerometer. Accuracy of $\pm 5\%$ up to at least 5000 cps by this method is assured. Endevco certifies by calibration that each accelerometer is linear $\pm 5\%$ to 5000 cps. Many of our accelerometers are rated linear $\pm 5\%$ to higher frequencies according to theoretical considerations. Every bit of evidence points to the acceptance of a theoretical curve for these higher frequencies.

FIELD TESTING:

In field testing many attempts are made to calibrate our accelerometers against some other dynamic measuring system. It should be noted that there are virtually no other types of accelerometers or displacement pickups which can be or have been dynamically calibrated at the high frequencies. It should also be noted that when any appreciable amount of material exists between the accelerometer being calibrated and the other measuring instrument it becomes increasingly uncertain at the higher frequencies that the

two devices are going through the same motions. This specifically applies to signal coil generators in vibration tables which are usually mounted some distance down from the vibrating table surface on which the accelerometer is mounted. In this case correlation cannot be expected beyond 1000 cps, and often 500 cps is the top limit.

SUMMARY:

The actual calibration of an Endevco accelerometer against a reciprocity standard has made it widely accepted as a useful standard of high frequency motion. The response is linear and will not change with time or treatment until some visual physical damage has taken place.

2.4 Transverse Sensitivity

Each Endevco accelerometer is tested for transverse sensitivity perpendicular to its sensitive axis. It is virtually impossible to make this measurement accurately on a vibrating shaker because a small side motion in the shaker will obscure the accelerometer's transverse sensitivity. Special mechanical shakers designed and built at Endevco are used for the transverse sensitivity measurements. These shakers operate at low frequencies of approximately 10 cps with total motion of an inch or more and less than .001 of an inch motion in the sensitive axis of the accelerometer. Each machine is equipped with a rotary table so that the accelerometer in motion is rotated about its sensitive axis for a full 360° and the maximum sensitivity in the transverse plane is located and measured to be certain that it is within specification.

Some Endevco accelerometers will have an arrow engraved on the top. This arrow indicates the direction of lowest cross axis sensitivity. It will be of use in aligning accelerometer when measuring small g levels where larger accelerations exist in a known transverse axis.



Testing for Cross Axis Sensitivity

Figure 5

III MAINTENANCE AND WARRANTY

3.1 Accelerometer Maintenance

Endevco accelerometers are designed to give many years of service without maintenance. Accelerometers which behave erratically should be checked for loose cable connections. Accelerometers exhibiting poor low frequency response are usually corrected by inspecting cables and connections with a megohmmeter to determine if a low resistance leakage path exists somewhere in the system. The insulation resistance of a properly operating system should be well above 10,000 megohms. It should be noted that wiping damp or oily fingers across the coaxial connectors will provide a leakage path well below this figure, resulting in poor low frequency response. Insulation resistance can be restored by wiping all connectors with a dry cloth.

It is recommended that all accelerometers be recalibrated every six months. If recalibration facilities are not available they may be returned and recalibrated at Endevco at a charge of \$10.00 each and a processing time of one week.

Accelerometers exhibiting characteristics not correctable in the field should be returned to Endevco for repair. Repair charges are nominal and usually include the incorporation of any new design techniques into the earlier models, bringing their specifications up to those of the latest units.

3.2 Cable Maintenance

Endevco does not repair any subminiature coaxial cables after initial failure. It is felt that these cables, once they have failed, are no longer reliable and should be replaced from our calibrated stock of cables. Additional unassembled connectors for cables may be purchased from the Microdot, Inc., South Pasadena, California - their Model 3221. A Model 3221-T Tool (approximately \$2.50 each) is necessary to assemble the connectors to the cable.

3.3 Warranty

The Endevco Corporation warrants each instrument manufactured by them to be free from defects in material and workmanship. Under this warranty any instrument returned to the factory will be serviced or adjusted without charge. This warranty is effective for one year after delivery date to the original purchaser when an instrument is returned transportation charge prepaid by the original purchaser and which, upon our examination, is disclosed to our satisfaction to be defective. If the fault has been caused by misuse or abnormal conditions of operation, repairs will be billed at standard charges. In this case a request for authorization to proceed with the work will be submitted before work is started.

3.4 Return of Equipment

All equipment being returned to Endevco Corporation regardless of warranty must be returned transportation charges prepaid. No authorization is required before return and Endevco will submit an estimate of repair cost before proceeding if the instrument is out of warranty.

IV REPLACEABLE PARTS LIST

ENDEVCO ACCELEROMETER ACCESSORIES

<u>Part No.</u>	<u>Description</u>	<u>Quantity</u>	<u>Unit Price*</u>
2211-0.2-A13	10-32 to 6-32 Accelerometer (2211, 2212, 2213, 2214) Mounting Stud Adaptor.		\$1.00
2211-0.2-A12	10-32 to 10-32 Accelerometer (2211, 2212, 2213, 2214) Mounting Stud Adaptor		1.00
3030 x 36"	3 foot Microdot 50-3804 noise- treated cable assembly with Microdot 3221 connectors on accelerometer end. Tested and labeled with exact capacity.	1-12	6.50
		13-33	6.40
		34-49	6.30
		50-124	6.15
3030 x ____"	Same as above but longer than 36" in length. (Less than 36" same price as above.) Additional price over 36"		0.05/in. or 0.60/ft.
3090 x ____"	Special High Temperature (500°F) noise-treated cable assembly for use at temperatures above 175°F. Price same as 3030 assemblies.		
2.31-2200-1.1	Accelerometer Instruction Manual		N/C
2.31-2000-1.1	Instructions for the Application of Piezoelectric Transducers		N/C

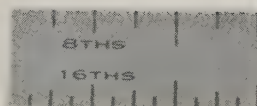
*All prices subject to change without notice.



SPECIFICATIONS

Printed USA 357

All units are supplied with individual calibrations and complete instruction manuals.



SUBMINIATURE ACCELEROMETER

Although subminiature it retains the advantages of Endevco's clamped crystal design--high natural frequency of 50 KC preventing harmonic distortion caused by lower natural frequency pickups and 5 millivolt/g sensitivity providing optimum signal to noise ratios.

A matching 3/8" tap as well as adapters for surface and through-hole mounting are supplied with each unit.

Printed USA 657

All units are supplied with individual calibrations and complete instruction manuals.



DYNAMIC MEASURING SYSTEMS

SERIES 2200 ACCELEROMETERS

Increasing use of Endevco accelerometers is based upon outstanding specifications resulting from:

- 1** New piezoelectric materials developed by Endevco.
- 2** Endevco "clamped crystal" designs respond to acceleration forces only.
- 3** Reliability of Endevco instruments and electronics.



Compare the following specifications with those of any other dynamic measuring instrument:

<i>High sensitivity</i>	 100 volts full scale (10,000 G's)
<i>High natural frequency</i>	. . . 35 KC to 70 KC
<i>Wide temperature range</i>	. . . Flat to 230°F (2200°F in Model 2205)
<i>Small size and weight</i>	. . . 1/3 to 1 ounce

Reliability is guaranteed by Endevco's controlled environmental testing and one year performance warranty. Endevco's unique policy for the modernization of older accelerometers to new design specifications insures against obsolescence. Service policy permits economic repair of units with damaged crystals.

IMPORTANT-HIGH SENSITIVITY:

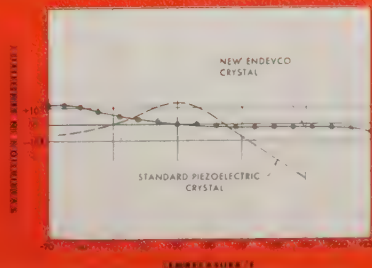
The amount of signal developed by an accelerometer for any G value compared to the noise in the system determines possible measurement accuracies. Endevco accelerometer's higher signal permits accurate measurement of even low acceleration levels. Microdot 50-3804 noise-treated cable is supplied with each accelerometer. It is the most noise-free cable of all commercial miniature coaxial cables tested. This combination of high signal level and low noise levels insures the greatest accuracy and flexibility.

IMPORTANT-HIGH FREQUENCY RESPONSE:

Piezoelectric pickups are linear $\pm 5\%$ to 1/5 of their natural frequency. Endevco's higher natural frequencies provide accurate performance over a wider and higher frequency range. Pickups with lower natural frequencies are subject to errors due to accelerometer ringing independently from the vibration or shock phenomena being measured. Lower natural frequency pickups require the use of filter elements which obscure information and introduce phase errors. Endevco pickups are provided with natural frequencies of 35 KC or higher. They can be used for both shock and vibration work without the use of error-producing filters.

IMPORTANT-TEMPERATURE LINEARITY:

Standard materials commonly used in piezoelectric instruments are usually non-linear with temperature. Endevco has developed new materials for use in their instruments that provide flat response over a wide temperature range (see curve). This material improvement in the field of piezoelectrics means greater accuracy, flexibility, and reliability under wide environmental conditions.



SPECIFICATIONS

Many Endevco accelerometers are available—see specifications below. Each model gives the optimum of any one feature such as: highest frequency response, highest sensitivity, or small size and light weight. Each, however, is a wide range instrument whose combination of specifications invite comparison.

MODEL	2211	2212	2213	2214	2205
(Replaced Model)	(2201) High Sensitivity High Frequency High G	(2202) High Sensitivity High Frequency Low mass	(2203) Highest Sensitivity General Laboratory & Telemetry Use	Highest Frequency Lowest Mass Highest G	Gas or liquid cooled for general use at temperatures to 2200°F.
Minimum Sensitivity: ¹ with 3' (100 mmfd) cable	9 mv/g	9 mv/g	15 mv/g	6 mv/g	15 mv/g
Frequency Response: ± 5% 1000 megohm load: ² ± 5% 100 megohm load:	2 cps to 10 KC 20 cps to 10 KC	2 cps to 10 KC 20 cps to 10 KC	2 cps to 7 KC 20 cps to 7 KC	2 cps to 14 KC 20 cps to 14 KC	2 cps to 4 KC 20 cps to 4 KC
Natural Frequency:	50 KC	50 KC	35 KC	70 KC	20 KC
Maximum Acceleration:	10,000 g	5,000 g	10,000 g	30,000 g	1,000 g
Minimum Acceleration: S/N=5/1	0.25 g	0.25 g	0.15 g	0.5 g	0.25 g
Cross Axis Sensitivity:	5% maximum in any axis—Each unit is tested in 30° increments				10% maximum
Linearity:	± 1%	± 1%	± 1%	± 1%	± 1%
Capacity: with 3' (100 mmfd) cable:	350 mmfd	350 mmfd	650 350 mmfd	350 mmfd	350 mmfd
Dimension H (see dwg):	0.55"	0.55"	0.65"	0.55"	1.4"
Material:	Stainless Steel	Aluminum	Stainless Steel	Aluminum	Stainless Steel
Weight:	0.7 oz.	0.4 oz.	1.0 oz.	0.3 oz.	4.0 oz.
Mounting:	10-32 x 1/8" tapped hole in accelerometer base with special stud for 6-32 mounting supplied				1/4-28 x .312 stud
Electrical Connections:	3 foot (100 mmfd) Microdot noise-treated cable assembly supplied				
Response to external forces such as: — 120 db noise — mounting torque	Less than 1%				Less than 1%
Temperature:	See curve: ± 10% from -65° to + 230°F				± 10% to 2200°F
Calibration:	Individual calibrations provided of sensitivity, capacity and frequency response from 20 cps to 5000 cps. Complete calibration procedure and application manual provided				up to 1000 cps

- ¹Average sensitivities are 25% higher than those specified. For vibration work using rms mv/pk g multiply by 0.707.
- ²Use Endevco Amplifiers—Models 2607, 2609 and 2614.
- ³Use Endevco Cathode Follower Model 2608.

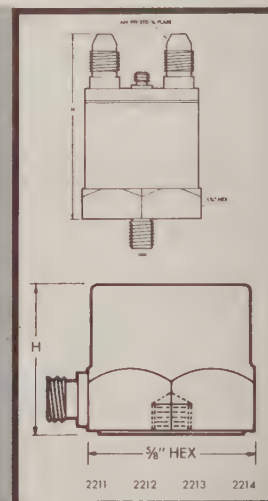
PRICES	2211	2212	2213	2214	2205
1 only	\$175.00 ea.	\$175.00 ea.	\$175.00 ea.	\$175.00 ea.	\$375.00 ea.
2 - 5	165.00 ea.	165.00 ea.	165.00 ea.	165.00 ea.	365.00 ea.
6 & over	150.00 ea.	150.00 ea.	150.00 ea.	150.00 ea.	350.00 ea.

ACCELERATION DIREC-
TION upward for positive
EMF on center terminal of
connector

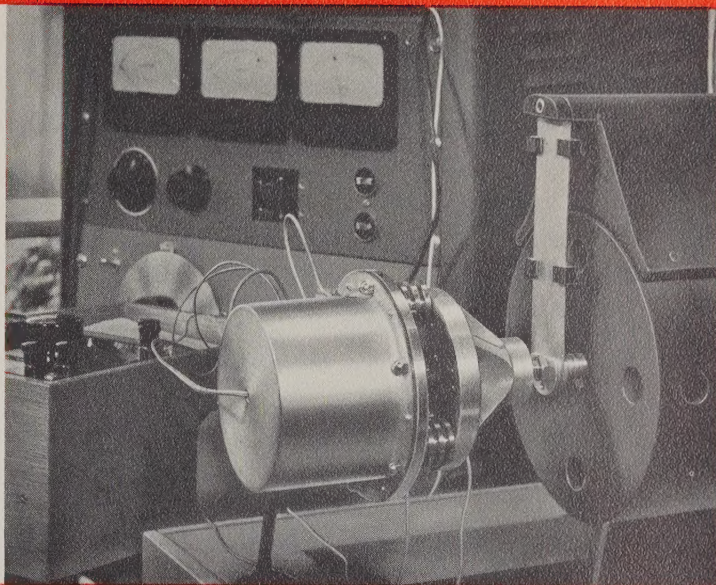
ELECTRICAL CONNEC-
TION Microdot 3101—
noise treated cable and
connectors supplied

MOUNTING—See chart
above

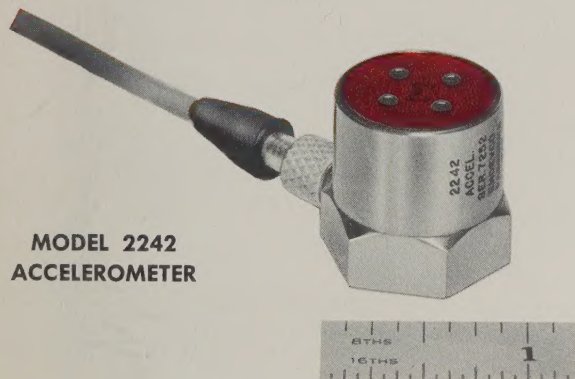
DIMENSION H—See chart
above



measures vibration
and shock at **500°F**
—without cooling
or correction



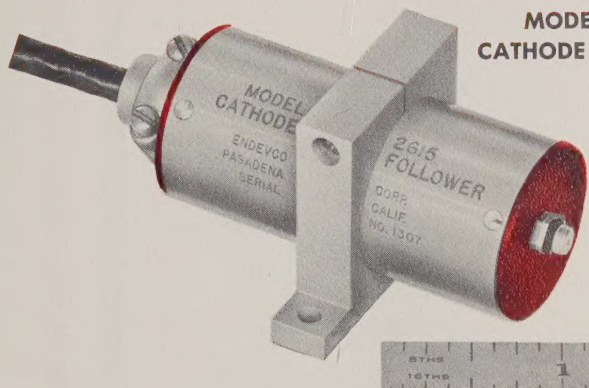
Accelerometer under test inside 70°F-500°F oven at 10g vibration
—Only 3% change in sensitivity.



**MODEL 2242
ACCELEROMETER**

Operating in an ambient temperature range of —65°F. to +500°F., the Endevco Accelerometer and Cathode Follower combination pictured above measures vibration and shock with an accuracy at $\pm 5\%$.

No cooling or temperature correction is needed in the Model 2242 Accelerometer. This unit uses PIEZITE element Type II—that functions at 500°F. with sensitivity down only 3%. The PIEZITE element Type II is an exclusive Endevco development supplying an output which is extremely linear with temperature. Sensitivity is 8 mv per g, and natural frequency is 25 kc—two features which provide large signal-to-noise ratios even at low g levels, and freedom from spurious resonant signals often present in accelerometers of lower natural frequencies. Linear low frequency response down to 25 cps is provided when used with Endevco Model 2615 Cathode Follower, and can be extended down to 5 cps when used with a 2607 Telemetering Amplifier, 2609 Galvanometer amplifier, or 2614 or 2616 Laboratory Amplifier.



**MODEL 2615
CATHODE FOLLOWER**

You can put the Cathode Follower right alongside the accelerometer in —65°F. to +500°F. ambient temperatures. With this close proximity, there's no loss of signal that would otherwise result from long cables running out of the high temperature area to distant units. All electronic components of the cathode follower are hermetically sealed in an inner housing which is vibration-isolated from the external housing. This construction provides a low noise system (0.20 mv/g) capable of accurate measurements.

With each accelerometer is supplied a #3090 $\times$ 36" all-Teflon noise-treated cable assembly which is operable at temperatures from —65°F. to +500°F. The cable retains its low noise properties over this entire range.

SUSTAINED SENSITIVITY

At 70°F. temperatures, the sensitivity is 8.6 mv/g

At 500°F. temperatures, the sensitivity is 8.4 mv/g—down only 3%

symbol of



excellence

ENDEVCO CORPORATION

161 East California Street, Pasadena, California

SPECIFICATIONS

model 2242

ACCELEROMETER

Minimum Sensitivity: ¹ with 3' (100 mmfd) cable	8 mv/g
Frequency Response: ± 5% 1000 megohm load: ² ± 5% 100 megohm load: ²	5 cps to 10 KC 25 cps to 10 KC
Natural Frequency:	50 ~~25~~ KC, minimum
Maximum Acceleration:	1,000 g
Minimum Acceleration: S/N = 5/1	0.25 g
Cross Axis Sensitivity:	5 ~~10~~ % maximum in any axis— Each unit is tested in 30° increments
Linearity:	± 1%
Capacity: with 3' (100 mmfd) cable	250 mmfd
Dimension:	½" hex—0.65" high
Material:	Stainless Steel
Weight:	1.0 ounce
Mounting:	10-32 x ¼" tapped hole in accelerometer base with special stud for 6-32 mounting supplied.
Electrical Connections:	3 foot (100 mmfd) No. 3090 noise-treated cable assembly supplied.
Response to external forces such as: 120 db noise mounting torque	Less than 1%
Temperature:	± 5% from -100° to +500° F
Calibration:	Individual calibrations provided of sensitivity versus temperature to 500° F, capacity and frequency response from 20 cps to 5000 cps. Complete calibration procedure and application manual provided.

¹For vibration work using rms/pk g multiply by 0.707.

²Use Endevco Amplifiers—Models 2607, 2609, 2614, and 2616.

³Use Endevco Cathode Follower Model 2608 or Model 2615.

model 2615

CATHODE FOLLOWER

ELECTRICAL

GAIN	0.94
INPUT IMPEDANCE	Over 100 megohms
FREQUENCY RESPONSE	25 cps to 20 kc, ± 2% with 10 K ohm load 5 cps to 20 kc, ± 1% with 500 K ohm load
VIBRATION	⅛" displ. or 200 g., whichever is exceeded first (200 microvolts/g).
AMPLITUDE LINEARITY	± 1% of full output
FILAMENT SUPPLY	4.5 to 6.5 vdc, 200 milliamps
PLATE SUPPLY	100 to 175 vdc, 3 milliamps

MECHANICAL

SIZE	2.4" x 1.1" (less bracket & cable)
WEIGHT	4 oz. (with cable—10 oz.)
MOUNTING	No. 6-32 on 1.69" centers
CONNECTORS AND CABLES	
Input	Microdot 3101
Output & Supply	Cannon RWK 622C-¼ on end of 10' cable. Other lengths available on special order.

ENVIRONMENTAL

TEMPERATURE	-65° F to +500° F
SHOCK	200 g—5 millise. rise time
PRESSURE	Hermetically sealed internal package. Outer package will breathe.

PRICES

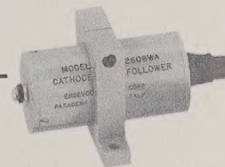
	2242	2615
1 only	\$495.00 each	\$275.00 each
2-5	475.00 each	265.00 each
6 & over	450.00 each	250.00 each

Delivery: In continuous production—check factory for firm delivery dates.

ENDEVCO INSTRUMENTATION ELECTRONICS

Cathode Follower, Model 2608

Subminiature, environmentally protected from vibration, etc., with Gain of 0.95 and frequency response from 2 cps to 20,000 cps.



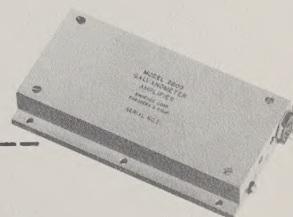
Telemetry Amplifier, Model 2607

A 50 millivolt input into 1000 megohms is amplified to 5 volts for telemetry oscillators with flat response from 2 cps to 20,000 cps. Designed for airborne environments.



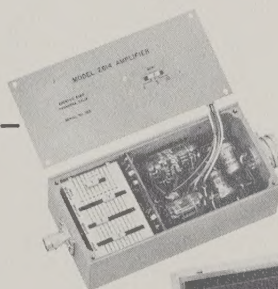
Galvanometer Amplifier, Model 2609

An output of 110 ma into 10 ohms for direct galvanometer operation over a frequency range from 5 cps to 5,000 cps are featured in addition to the Model 2607 characteristics.



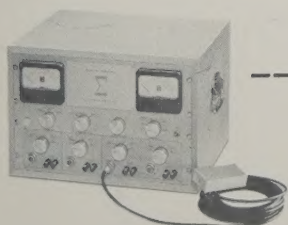
Laboratory Input Amplifier, Model 2614

Impedance transformation from 1000 megohms to 2500 ohms, with voltage Gains of 1, 3, and 10, and an input pickup standardizer, make this an ideal general purpose laboratory unit.



Power Supplies, Model 2621 and 2622

AC operated with an extremely low noise DC filament and plate supply for Models 2607, 2608, 2609, and 2614.



Meters and Analyzers

Special purpose vacuum tube voltmeters and analyzers reading in RMS, Peak to Peak, and Pulse Peak volts with high current. Gains to 30 ma. System frequency response from 2 cps to 100,000 cps.

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